NASA King Air B200 Deployment Plans for TEXAQS II/GoMACCS

NASA LaRC

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Project Description

- Deploy 4 down-looking optical remote sensing instruments to measure aerosol spatial distribution and optical properties
  - **High Spectral Resolution Lidar (HSRL) – Primary instrument**
  - Hyperspectral Polarimeter for Aerosol Retrievals (HySPAR)
  - Langley Airborne A-band Spectrometer (LAABS)
  - Digital camera (for context)

- Platform
  - NASA Langley King Air B-200
  - 27-28 kft nominal flight altitude
  - 80-100 flight hours

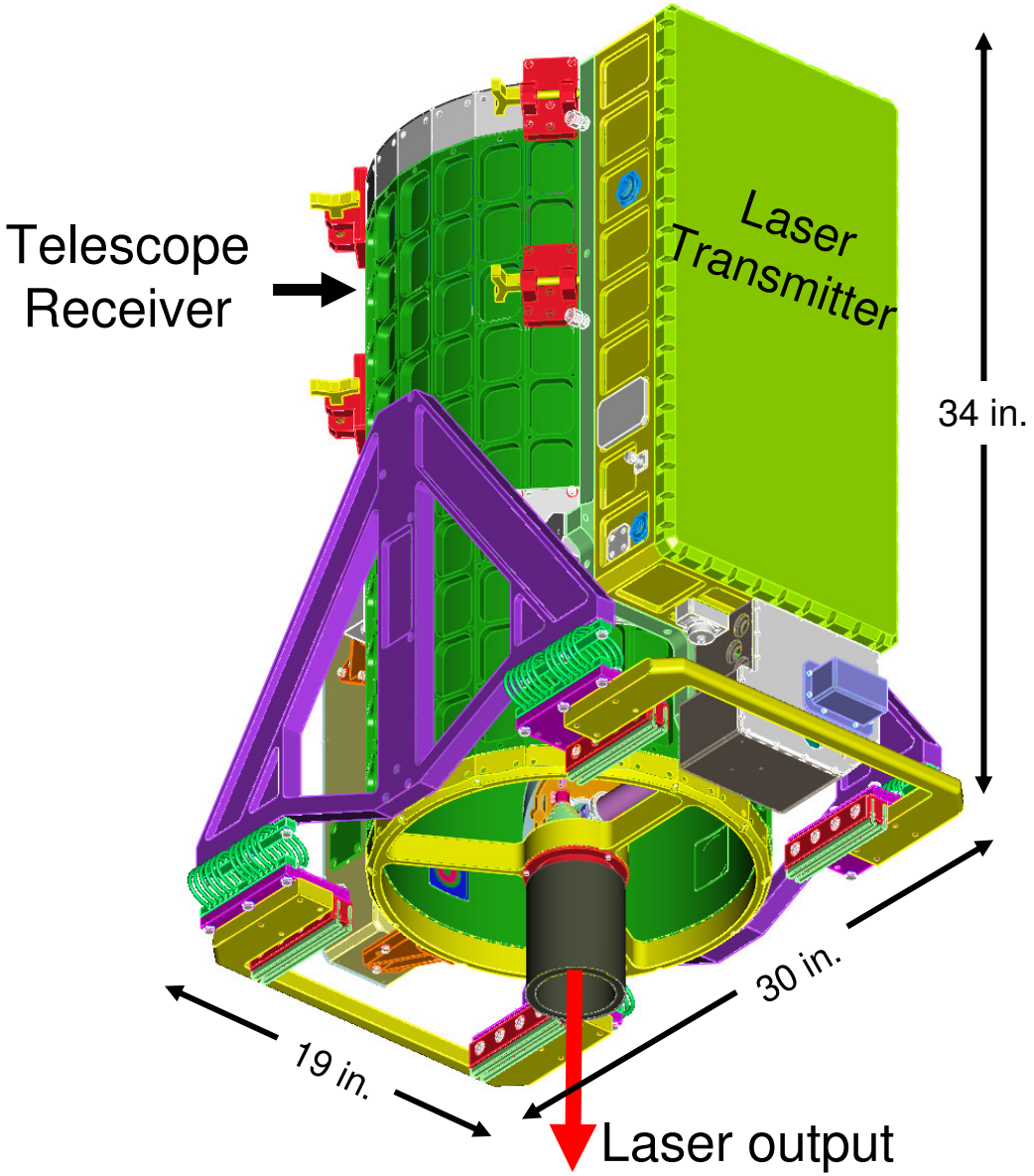
- Objectives
  - Augment TEXAQS/GoMACCS radiation and air quality science objectives
  - Validate CALIOP lidar on the CALIPSO satellite
  - Assess aerosol measurements of existing passive satellite sensors
    - MODIS, MISR, PARASOL
  - Investigate new remote sensing strategies and retrieval techniques

- Deployment schedule: 15 August – 15 September

Science Objectives

- Map vertical and horizontal distribution of aerosols
  - Use profiles of extinction, backscatter, and depolarization to characterize the vertical distribution of aerosol by type (e.g. dust, sulfate, sea salt, etc.)
  - Determine relative contribution of various aerosol types to aerosol extinction and optical depth
  - Characterize the behavior and variability of the ABL height
  - Evaluate transport model predictions of aerosol distributions and transport in Houston region
  - Provide vertical context for in situ measurements on the P-3 and Twin Otters
  - Provide advance or real-time information to vector other aircraft to locations and altitudes of greatest interest
  - Evaluate the distribution of aerosol backscatter/extinction in the proximity of clouds
- Validate CALIPSO backscatter, extinction, and depolarization measurements
- Investigate use of lidar data in combination with and MODIS and PARASOL to determine vertical distribution of aerosol effective radius, fine mode fraction as a prelude to combined CALIPSO/A-train retrievals
- Investigate the combined use of lidar, photo-polarimeter, and oxygen A-band data to characterize key aerosol optical and microphysical properties

Airborne High Spectral Resolution Lidar

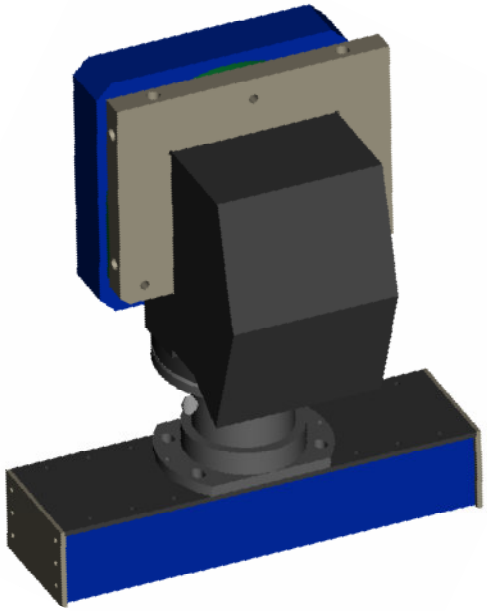


- Independently measures aerosol/cloud extinction and backscatter at 532 nm
- Includes
  - Backscatter channels at 1064 nm
  - Polarization sensitivity at 532 and 1064 nm
- Measurement capabilities
  - Extensive measurements
    - Backscatter at 532 and 1064 nm
    - Extinction at 532 nm
  - Intensive measurements
    - Color ratio (or Angstrom coeff.) for backscatter (β_{1064}/β_{532})
    - Extinction-to-backscatter ratio at 532 nm
    - Depolarization at 532 and 1064 nm

HyperSpectral Polarimeter for Aerosol Retrievals
PIs: Yongxiang Hu, David Flittner

- Fundamental measurements
  - Full stokes vector (including circular polarization)
  - Continuous spectral coverage from 412 to 865 nm at 20 nm spectral resolution
  - Multi-angle viewing geometry: +/- 60º along flight vector

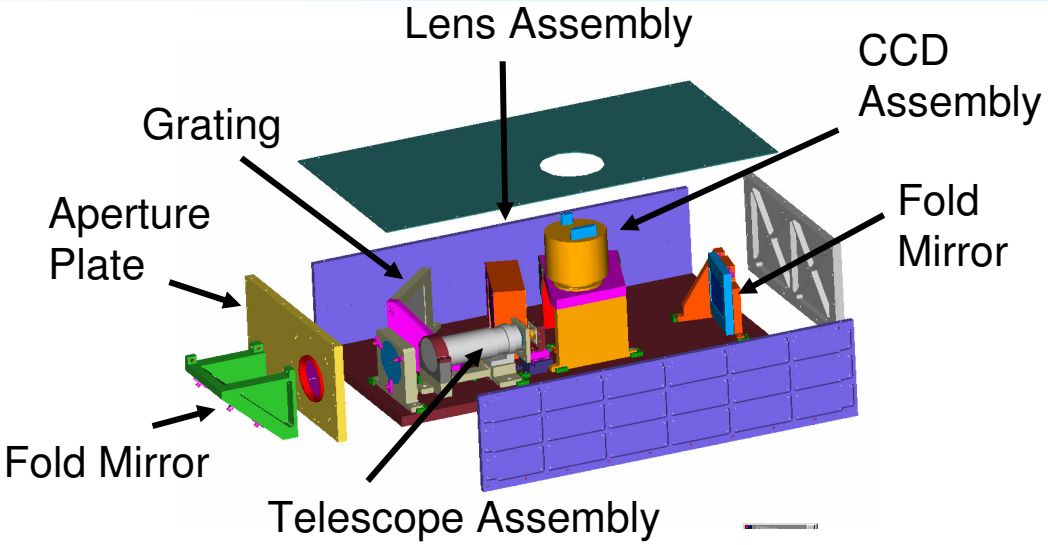
- Retrieval goals
  - scattering optical depth
  - Angstrom coefficient
  - asymmetry parameter
  - size distribution
  - complex index of refraction
  - single scatter albedo



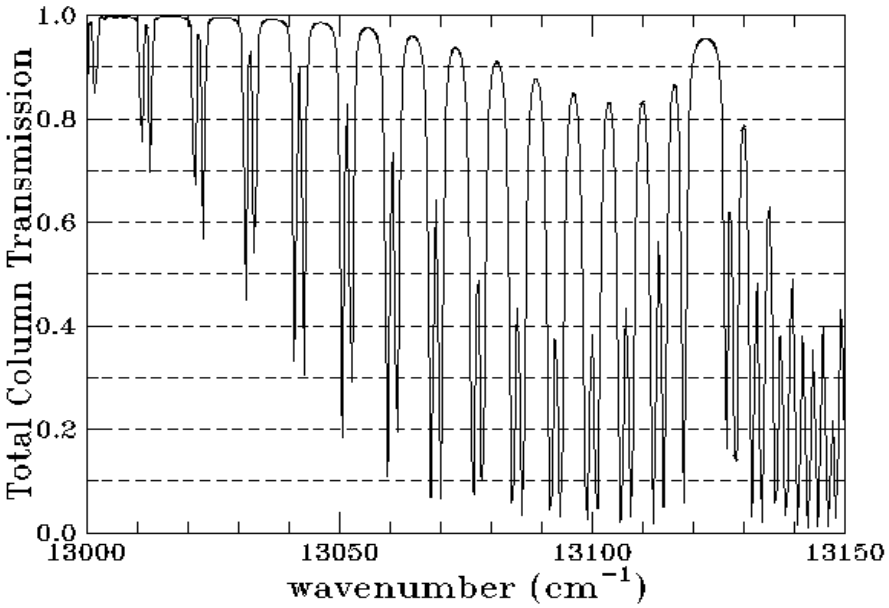
Built by Aerodyne Research, Inc.,

Langley Airborne A-band Spectrometer (LAABS)
PI: Mike Pitts

- Fundamental measurement
  - Spectrum of upwelling radiances in the oxygen A-band (760-770 nm)
  - 0.03 nm spectral resolution



- Retrieval goals
  - surface pressure
  - optical depth of aerosol layers
  - aerosol single scatter albedo



LaRC King Air B200

Altitude	35,000 ft (10.7 km), maximum operating
Range	800 nmi (1,300 km) at sampling speed
Endurance	3.8 hr, maximum (with IFR reserve)
Speed	259 KIAS (133 m/s) cruise

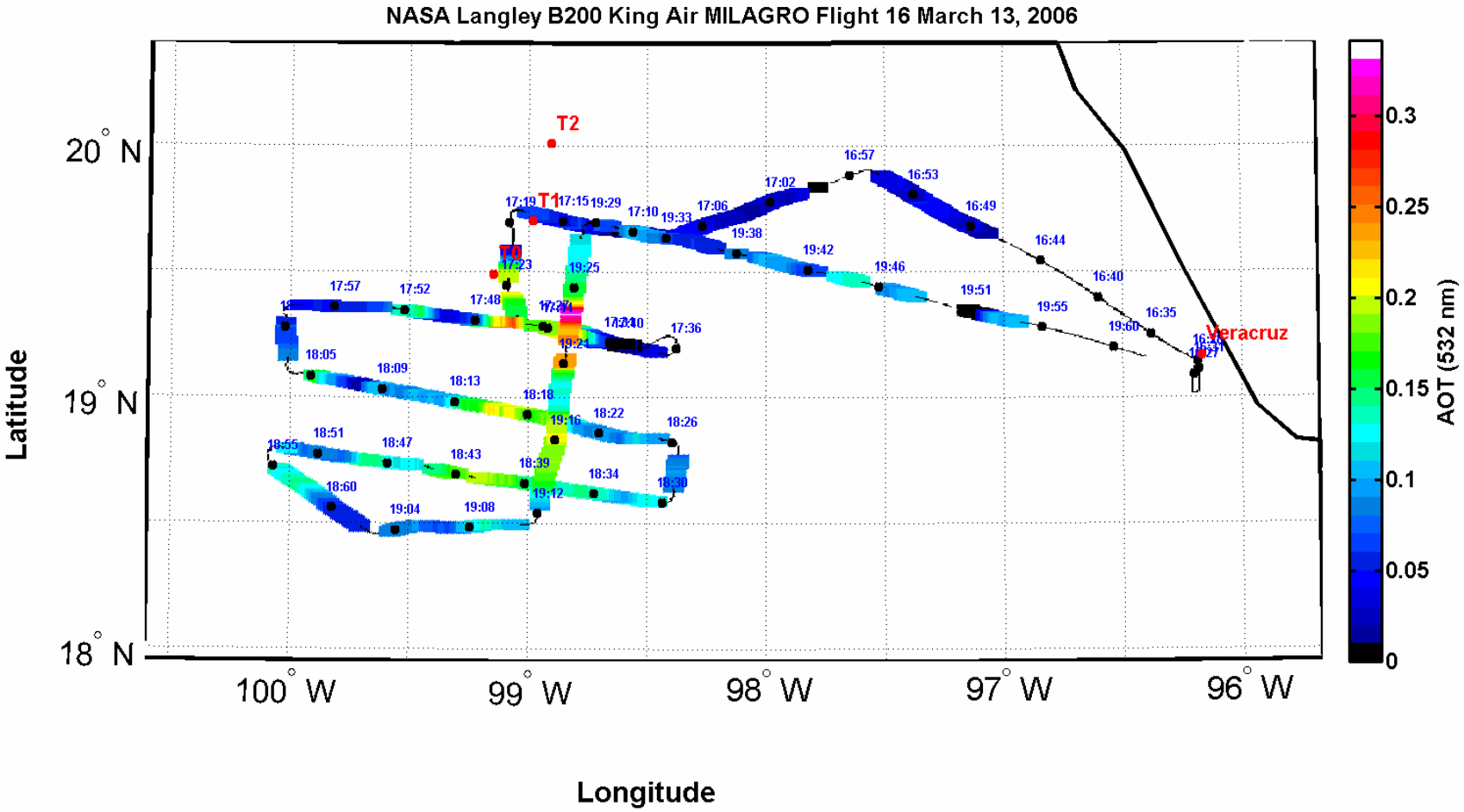
Payload	2500 lb (1,136 kg), maximum 500 lb (227 kg), with full fuel
Electrical Power	2 250A 30V DC generators, 3 1400VA, 400 Hz inverters supply 115V AC
Comm.	Iridium phone and modem

Some Preliminary Results from MILAGRO

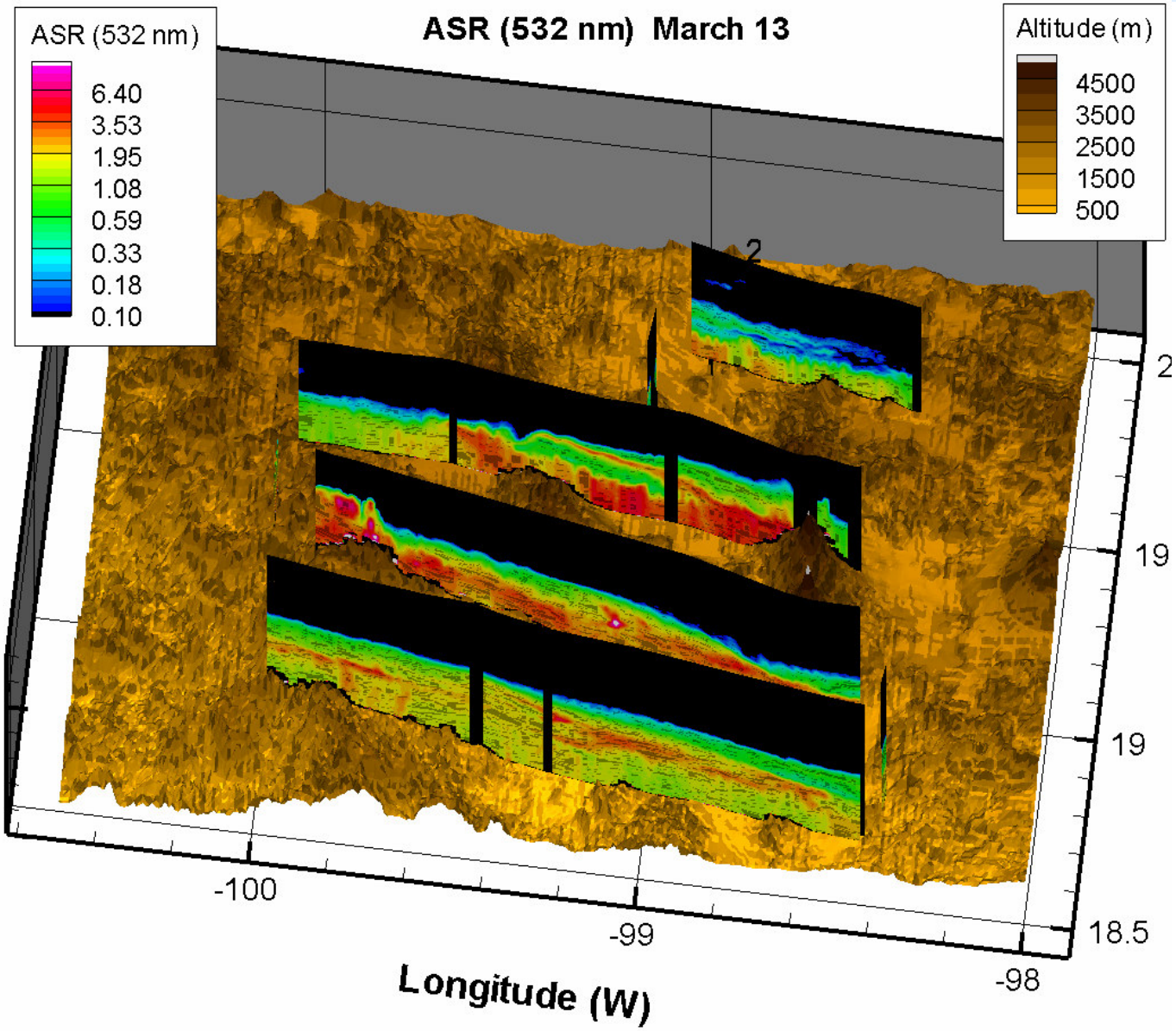
- Sponsored by NSF, DOE, NASA, and Mexico
- Objective: study Mexico City pollution transport and evolution
- Large-scale campaign
  - 3 extensively outfitted ground sites
  - 5 aircraft: C-130, DC-8, G-1, J-31, Twin Otter, B-200

HSRL observations from MILAGRO: 13 March "raster pattern" over Mexico City Metropolitan Area

Raster patterns typically coordinates with observations from NASA J31 or DOE G1

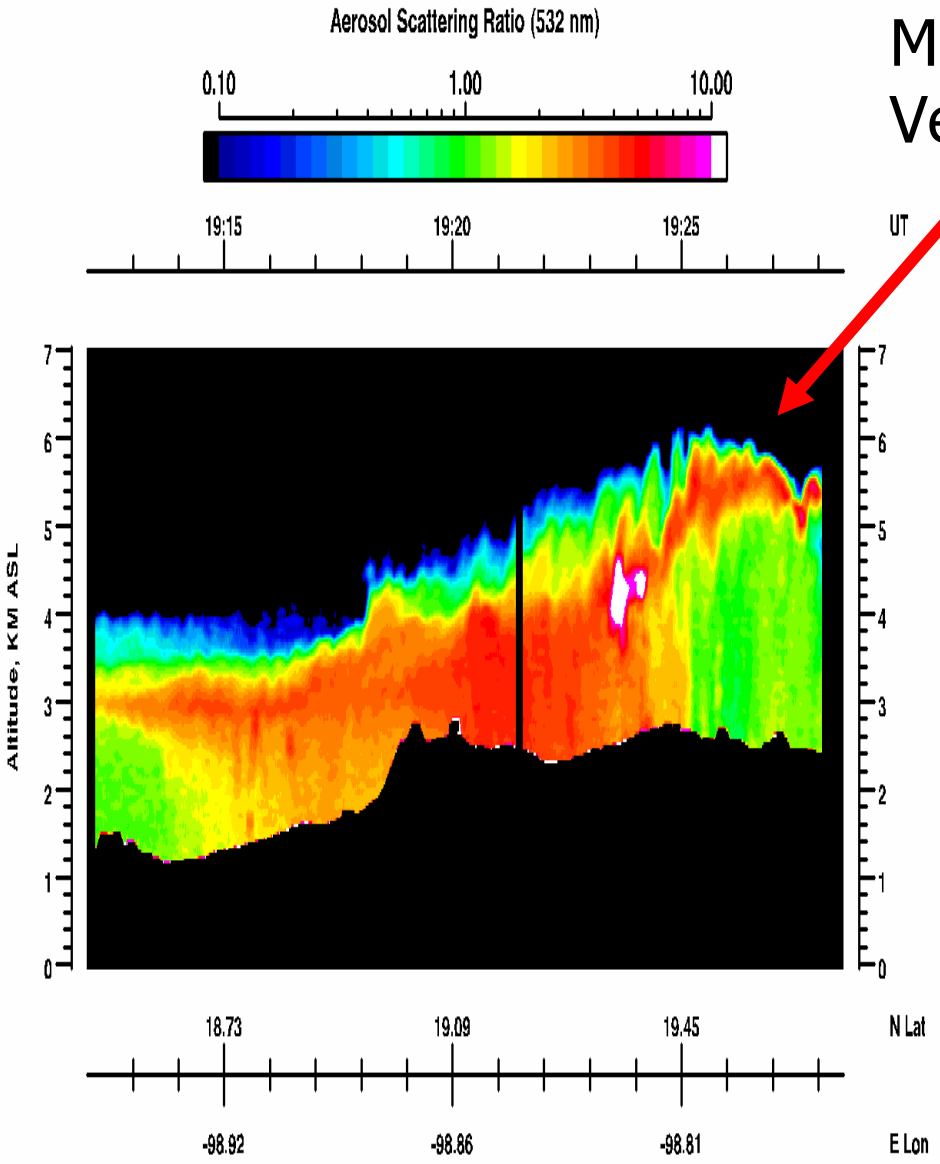


Mapping the vertical and horizontal distribution of aerosols over Mexico City



March 13
Raster scan

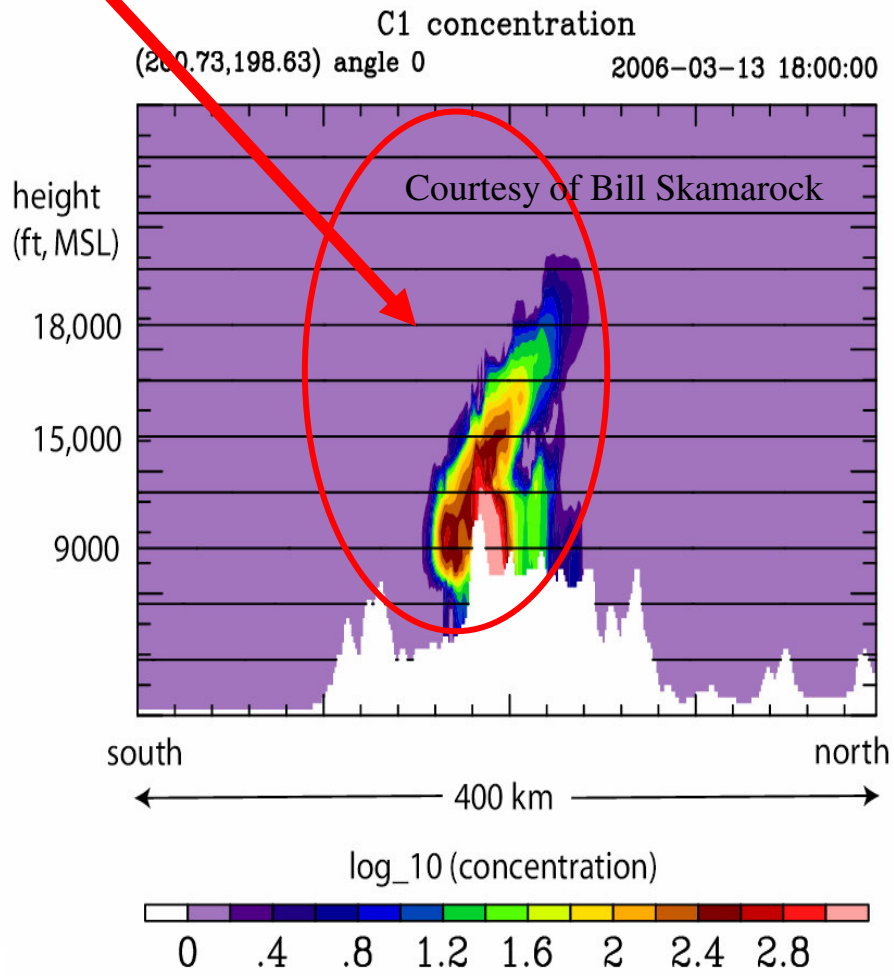
Evaluating model predictions



Mountain Venting

March 13

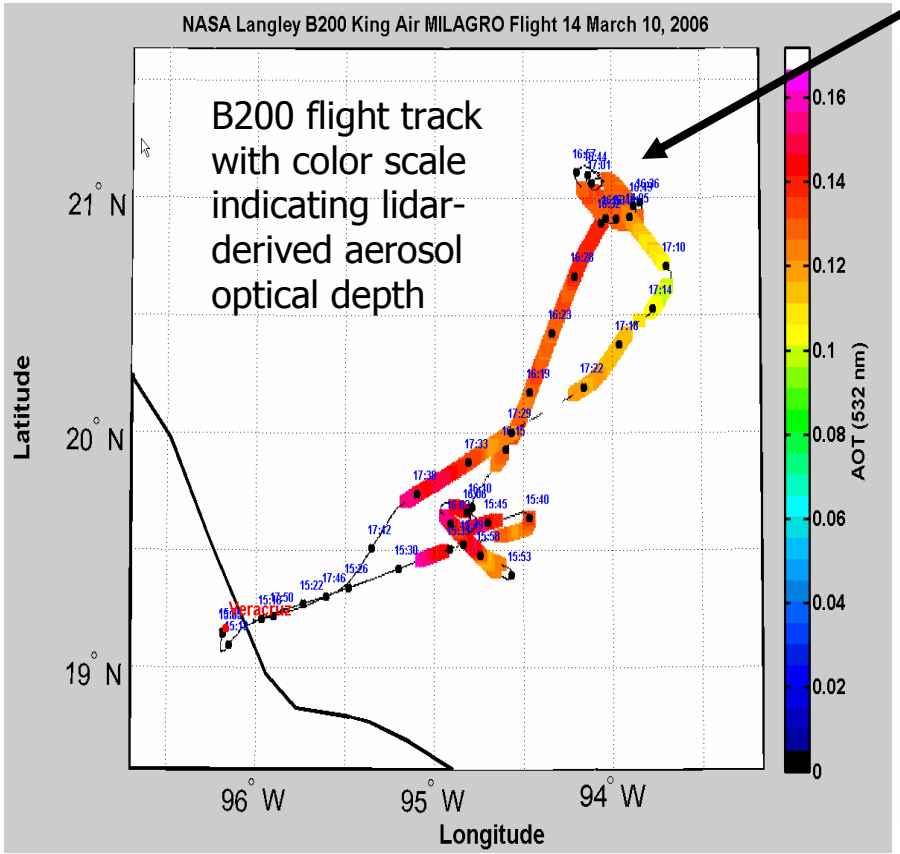
WRF 18 hour forecast

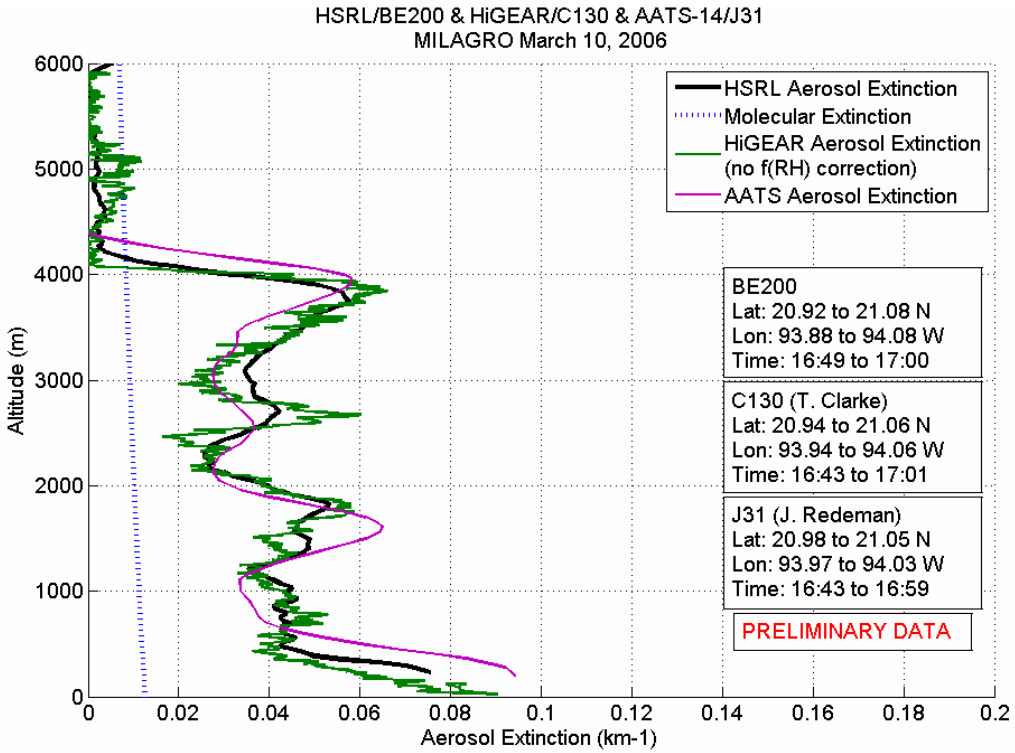


MILAGRO Extinction Profile Comparison

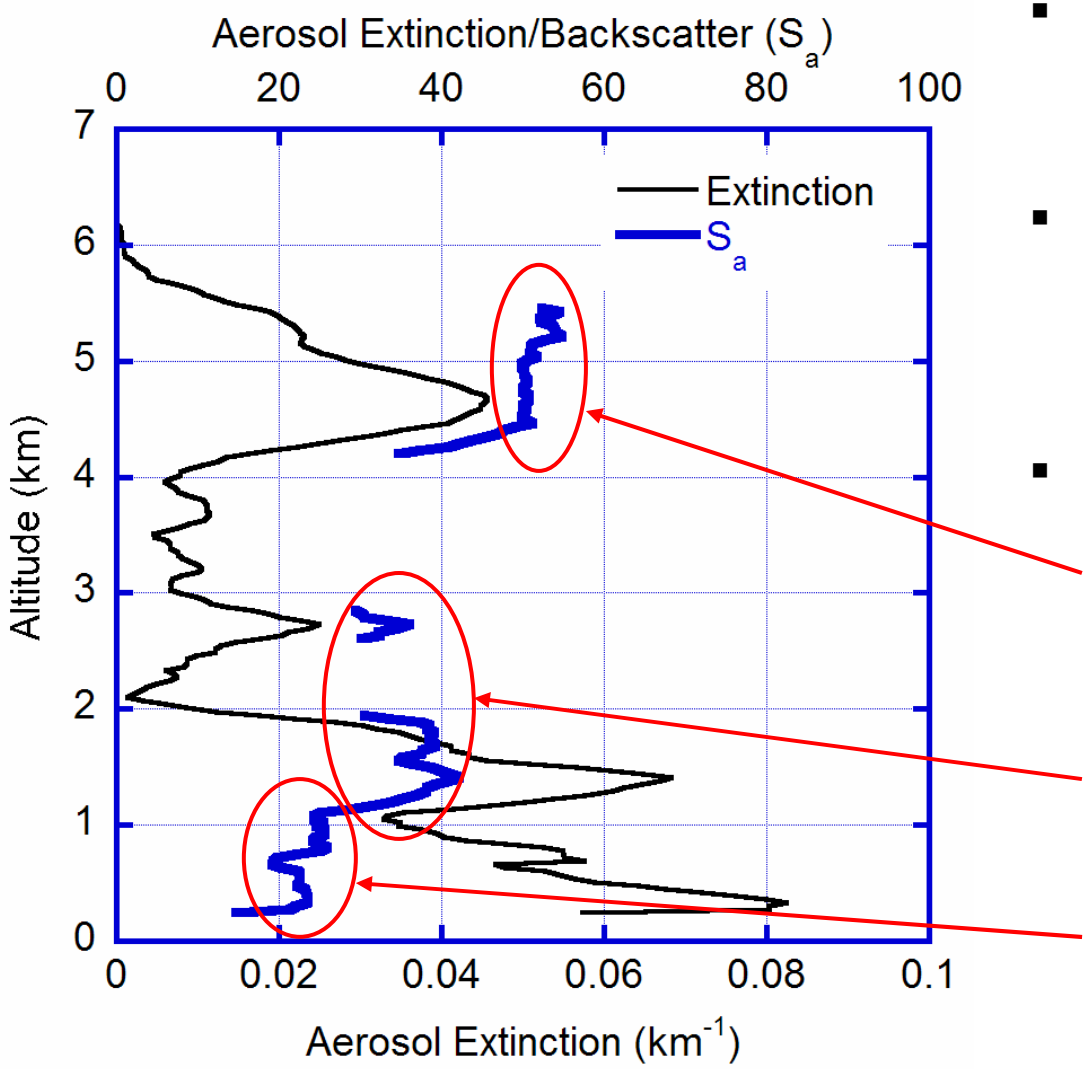
- Comparison of HSRL aerosol extinction/optical thickness with AATS14 on J-31 and HIGEAR on C130
  - AATS14 data courtesy of Phil Russell, Jens Redemann, John Livingston
  - HIGEAR data courtesy of Tony Clarke

Spiral location for J31 & C130



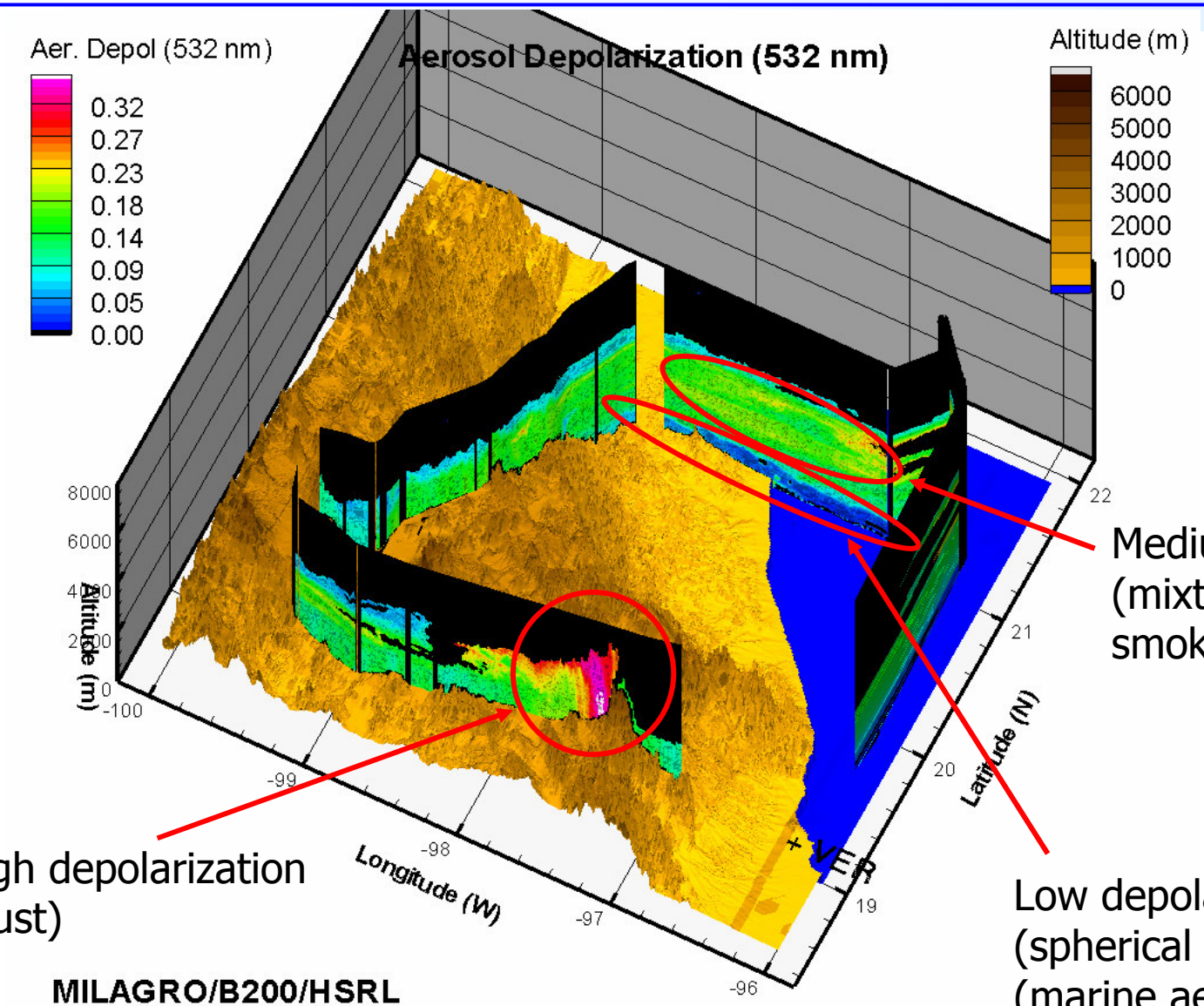


Layers of different aerosol type inferred from extinction-to-backscatter ratio (S_a)



- Extinction-to-backscatter ratio (S_a) depends on aerosol type not amount.
- Data shown are from 28 March flight over Gulf of Mexico east of Veracruz (19.76N, -95.31W, 16:36UT)
- Three regimes in S_a observed
  - Highest S_a of upper layer (4.5-5 km) possible indication of biomass smoke
  - Intermediate S_a of layers at 2.5 and 1.5 km similar to pollution seen over Mexico City
  - Low S_a of lowest layer consistent with sea salt dominated maritime aerosol

Characterize the vertical distribution of aerosol types



Medium depolarization (mixture of dust, smoke, and pollution?)

High depolarization (dust)

Low depolarization (spherical particles: (marine aerosol, pollution?)

MILAGRO/B200/HSRL
Flight 15, March 12, 2006
Terra Overpass in Gulf and Mexico City Overpass

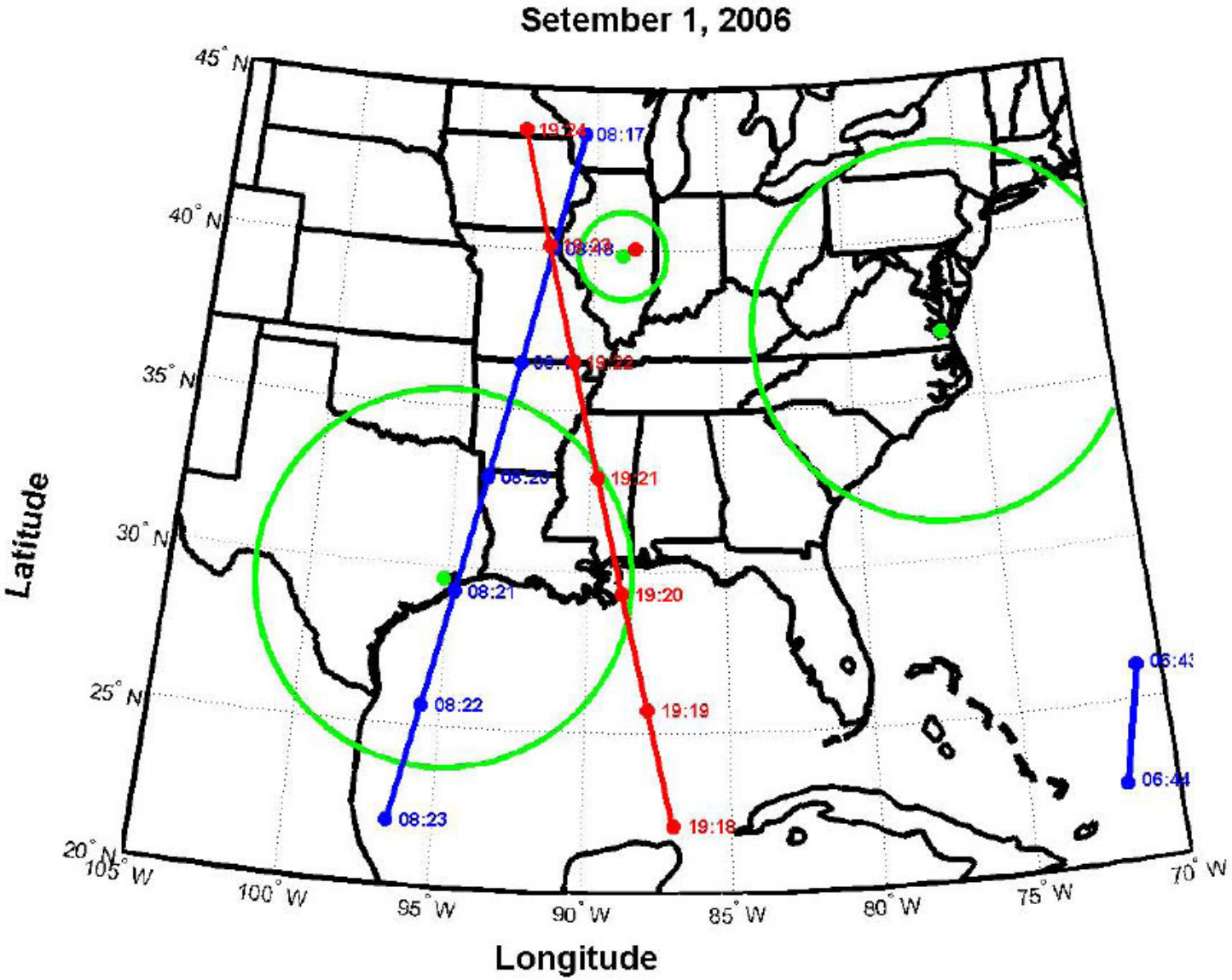
CALIPSO Validation

- In addition to contributing to the radiation and air quality science from TexAQS II / GoMACCS, the HSRL will fly several sorties to support CALIPSO validation.

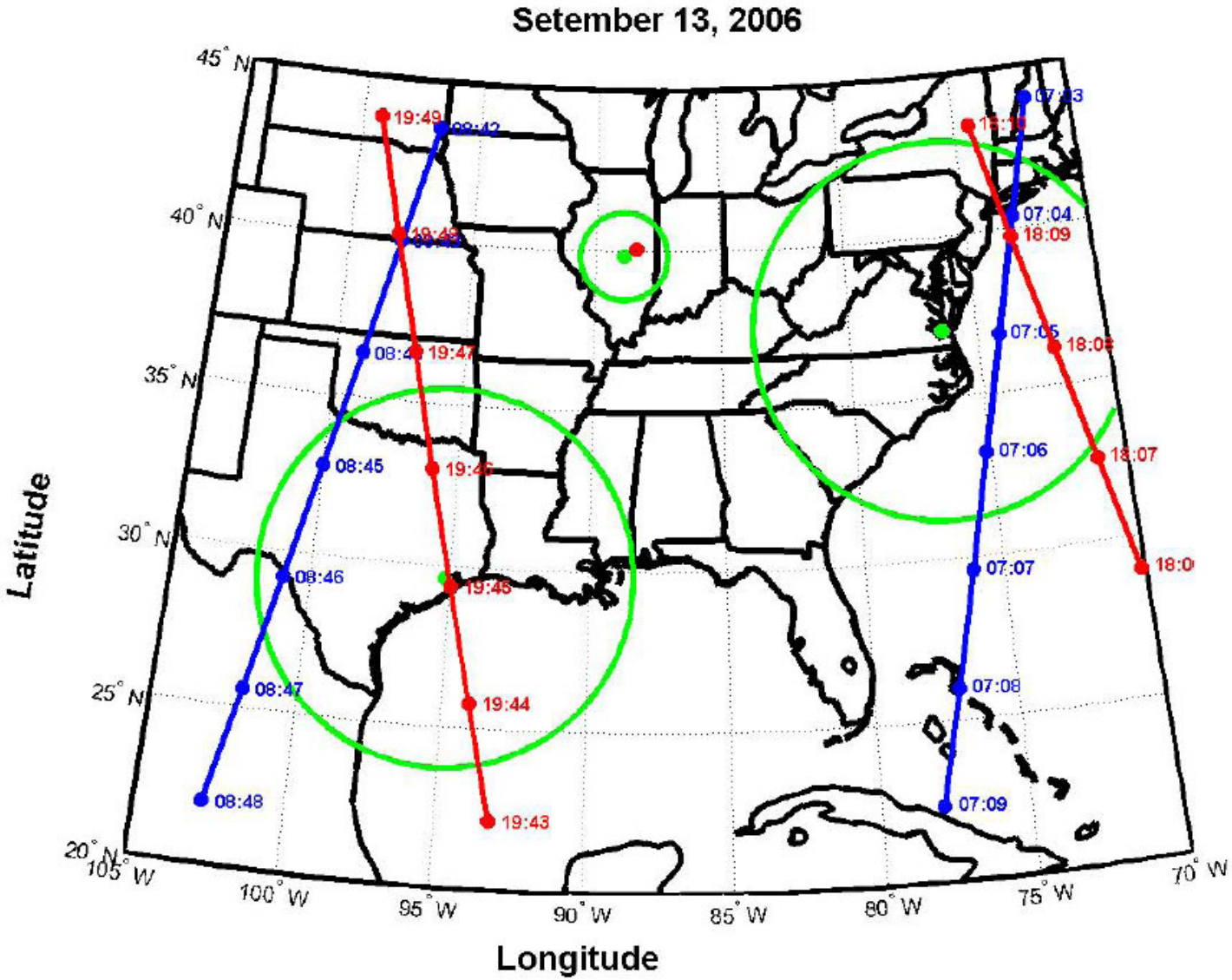
- The following 2 charts show examples CALIPSO ground tracks that fall within easy reach of the Houston deployment site.
  - The circle centered on Houston indicates the approximate maximum range of the B200 (assuming return to Houston).

- Other TexAQS II / GoMACCS participating aircraft will be encouraged to participate in validation and science underflights of the CALIPSO satellite as well.

CALIPSO Ground Track



CALIPSO Ground Track



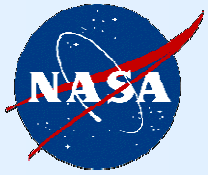
Data Products

Data Products

- Standard Data Products
  - HSRL-derived profiles of
    - Backscatter coefficient at 532 and 1064 nm ($\Delta x<500$ m, $\Delta z=30$ m)
    - Extinction coefficient at 532 nm ($\Delta x\sim10$-20 km, $\Delta z=200$-300 m)
    - Aerosol depolarization at 532 and 1064 nm ($\Delta x<500$ m, $\Delta z=30$ m)
- Research Products (goals)
  - LAABS ($\Delta x\sim1$ km)
    - Optical depth at 765 nm
    - Single scatter albedo
  - HySPAR ($\Delta x\sim1$ km)
    - Optical depth
    - Angstrom coefficient (scattering extinction)
    - Asymmetry parameter
    - Size distribution
    - Complex index of refraction
    - Single scatter albedo

Desired External Data

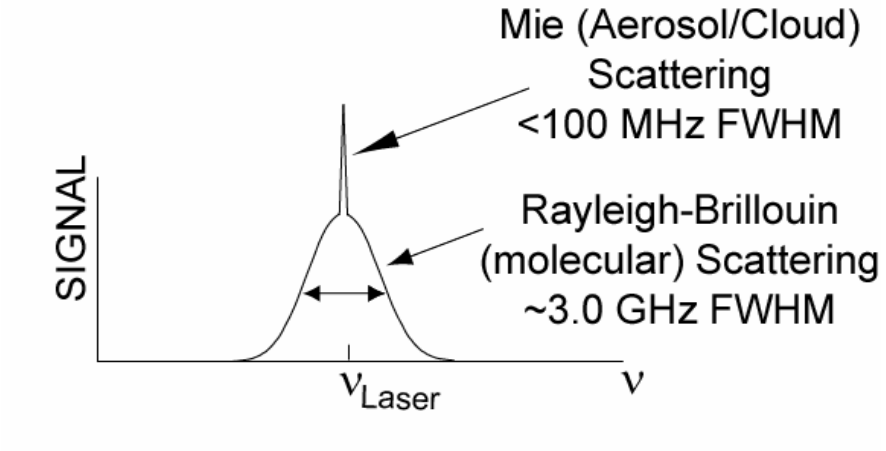
- Desired products from in situ measurements and models (for science analysis, i.e., not required for producing our products)
  - Temperature profile
  - RH, f(RH)
  - Aerosol size distribution (under ambient RH, if possible)
  - Absorption/scattering coefficients
  - Aerosol composition
  - Aerosol refractive index
- Desired Products for investigating active-passive retrievals
  - Aerosol asymmetry parameter
  - Surface spectral albedo
  - Sea surface wind speed/direction



Backups

High Spectral Resolution Lidar (HSRL)

HSRL relies on spectral separation of aerosol and molecular backscatter in lidar receiver.



- HSRL independently measures aerosol and molecular backscatter
  - Can be internally calibrated
  - No correction for extinction required to derive backscatter profiles
  - More accurate aerosol layer top/base heights

- HSRL enables independent estimates of aerosol backscatter and extinction
  - Extinction and backscatter estimates require no S_a assumptions
  - Provide *intensive* optical data from which to infer aerosol type
  - Measurements of extinction at 2 wavelengths and backscatter at 3 wavelengths enables retrieval of aerosol microphysical parameters and concentration